ACE-FTS and ozone depleting substances

Patrick Sheese[1]

Kaley A. Walker[1], Chris D. Boone[2], Laura Saunders[1],

Martyn Chipperfield[3], Sandip Dhomse[3]

[1]University of Toronto

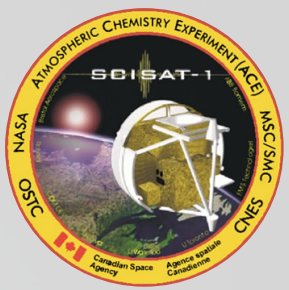
[2]University of Waterloo

[3]University of Leeds

Aura Science Team Meeting, Pasadena, California, 27 Aug 2019

ACE-FTS

Atmospheric Chemistry Experiment – Fourier Transform Spectrometer



- Canadian satellite SciSat was launched in August 2003
  - Just celebrated its sweet 16!

- ACE-FTS is a solar occultation, limb viewing instrument
  - High spectral resolution FTS in the 2.2 to 13.3 μm spectral range
  - Vertical resolution of 3-4 km, ~6-120 km altitude range

- 74 trace species are retrieved, including:
  - CFC-11, HCFC-22, HCFC-142b, CFC-12 CFC-113, HCFC-141b, HFC-134a, HFC-23

- Level 2 version 4.0 data were used in this study

New version 4.0 level 2 data

New version for ACE-FTS has been released, with new IMAGERS version

- includes more species/isotopologues

Routine species

- Tracers: H_2O, O_3, N_2O, NO, NO_2, HNO_3, N_2O_5, H_2O_2, HO_2NO_2, N_2, O_2, SO_2
- Halogen-containing gases: HCl, HF, $ClONO_2$, CFC-11, CFC-12, CFC-113, COF_2, $COCl_2$, COFCl, ClO, CF_4, SF_6, CH_3Cl, CCl_4, HCFC-22, HCFC-141b, HCFC-142b, HFC134a, HFC-23
- Carbon-containing gases: CO, CH_4, CH_3OH, H_2CO, HCOOH, C_2H_2, C_2H_6, OCS, HCN, acetone, CH_3CN, PAN, CO_2 in lower atmosphere, and pressure / temperature from CO_2 lines
- Isotopologues of: H_2O, CO_2, O_3, N_2O CO, CH_4, OCS, NO_2, HNO_3

Chris Boone

ODS trends comparisons with SLIMCAT/TOMCAT

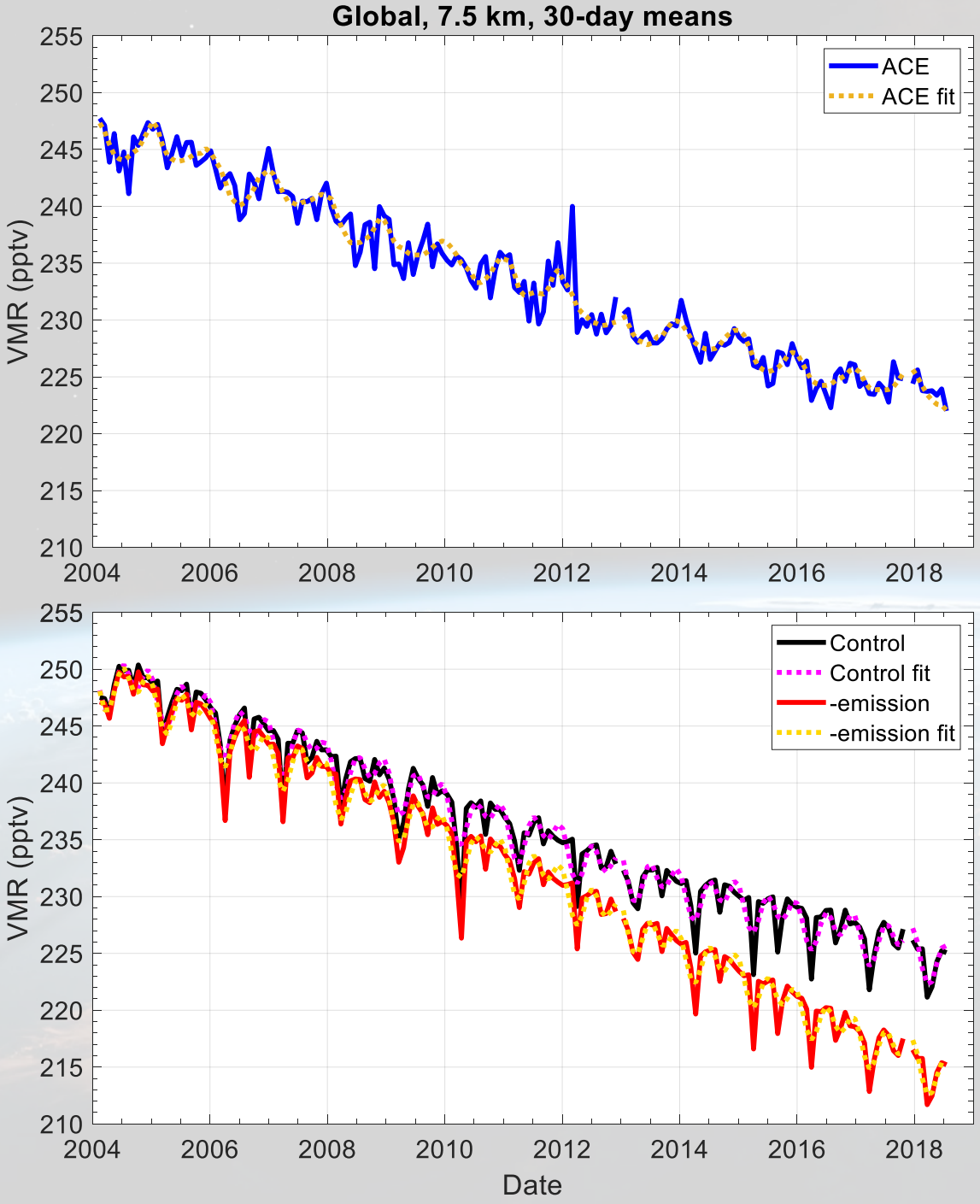
SLIMCAT/TOMCAT

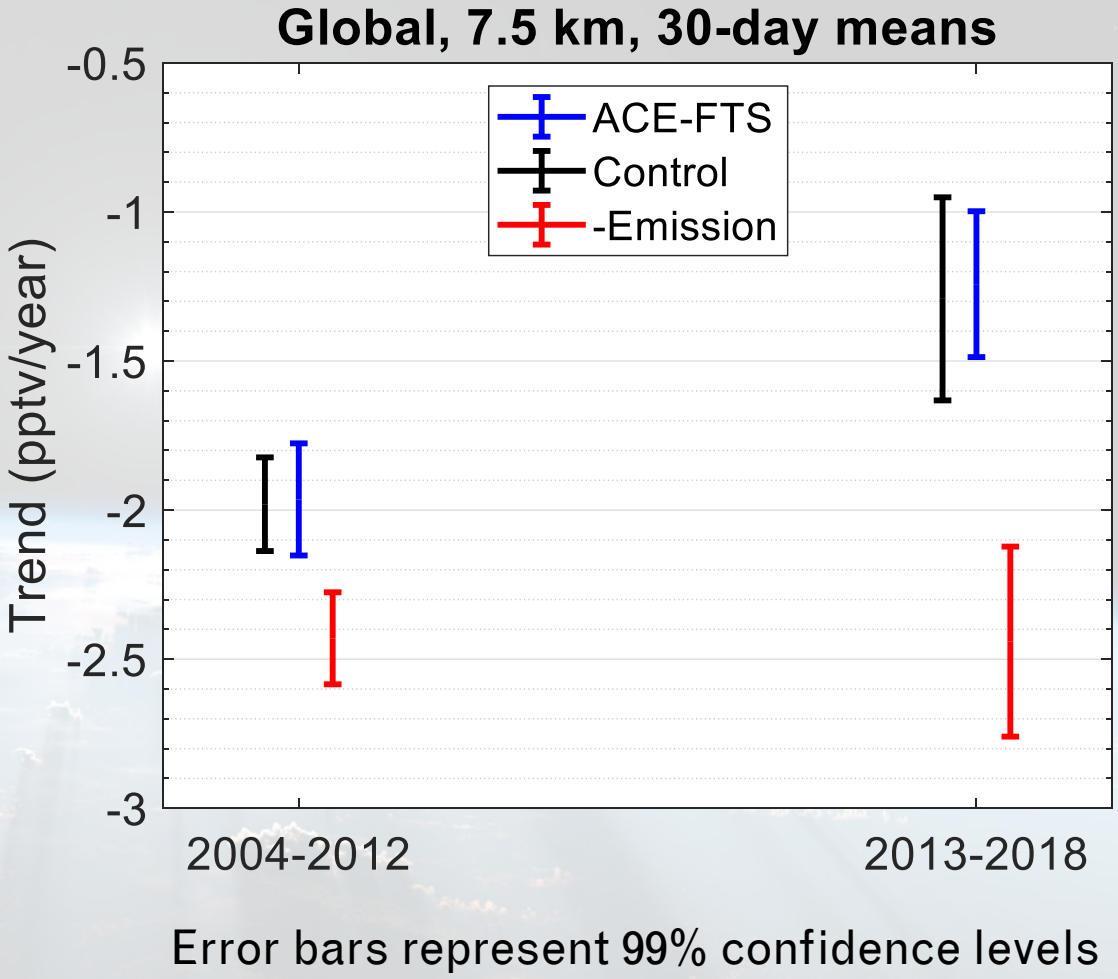
- 3-D chemical transport model
  - Model output data was sampled at ACE-FTS locations

- CFC-11: Two different runs, with different surface CFC-11 inputs:
  - Control run: input is global average surface measurements (up to 2017)
  - -emission run: input is global average minus "extra" emissions

- HCFCs: Two different runs with different surface HCFC inputs
  - 2014 WMO ozone assessment values
  - 2018 WMO ozone assessment values (*both have same values before 2013*)

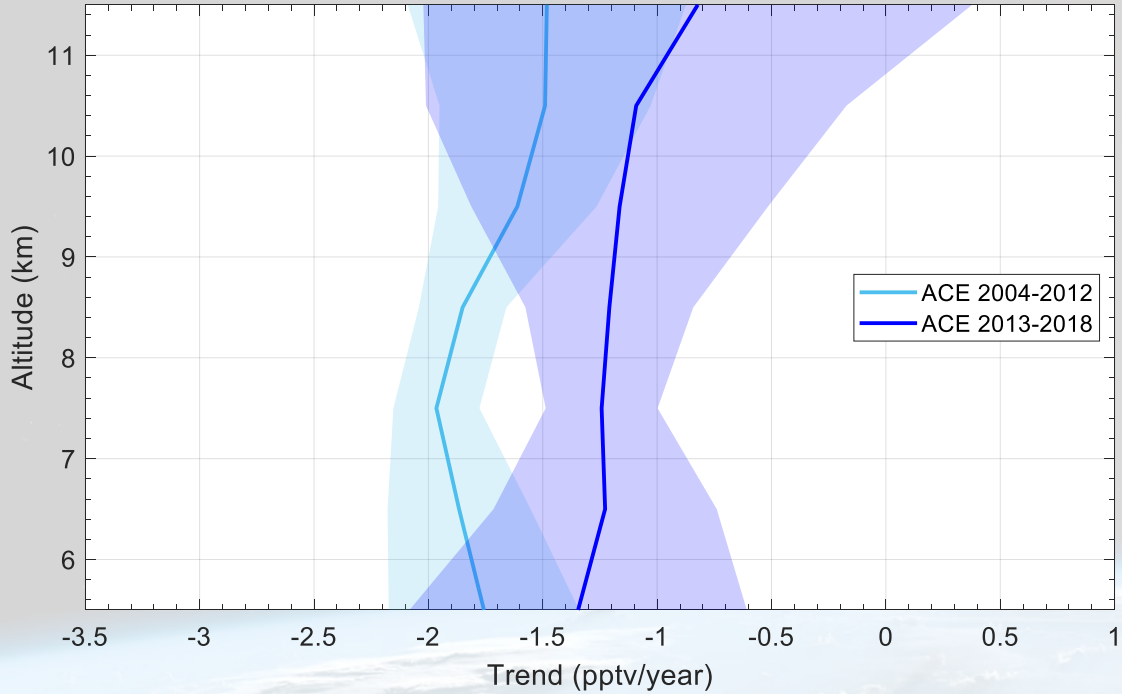
CFC-11



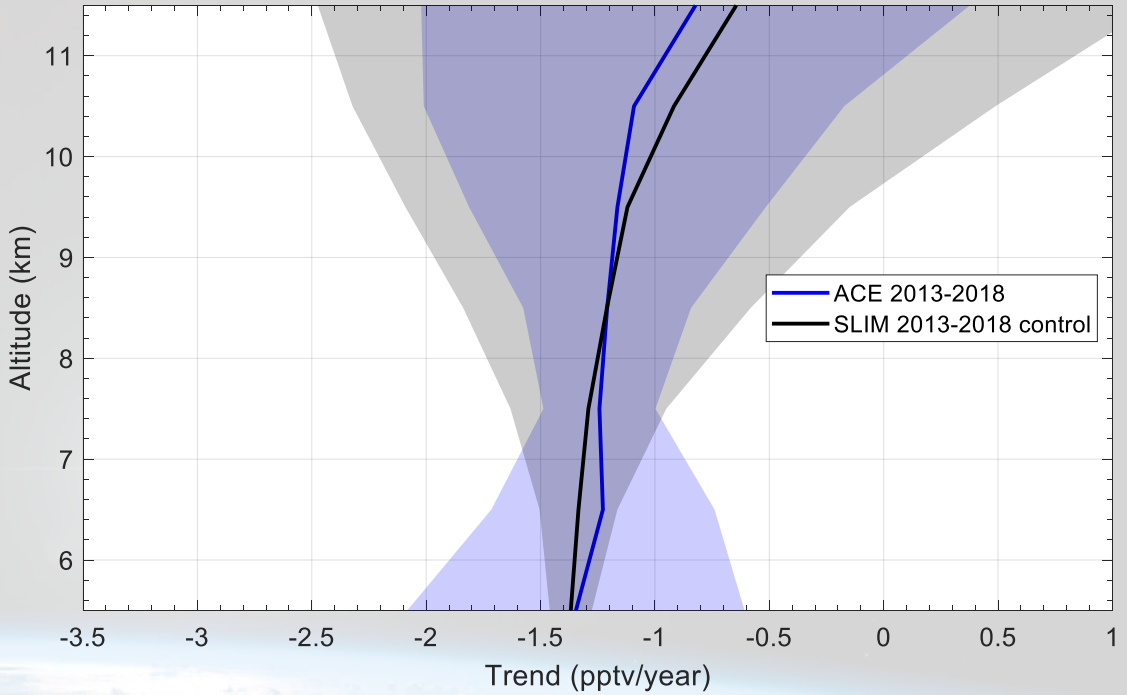


Error bars represent 99% confidence levels

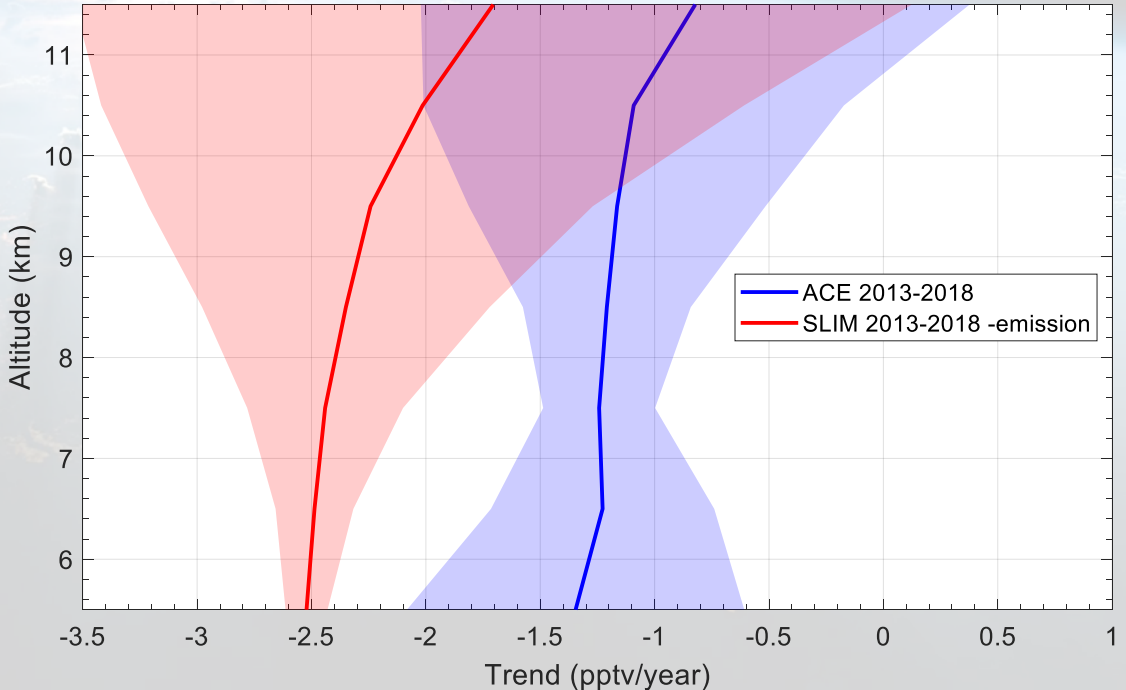
Global trend profiles



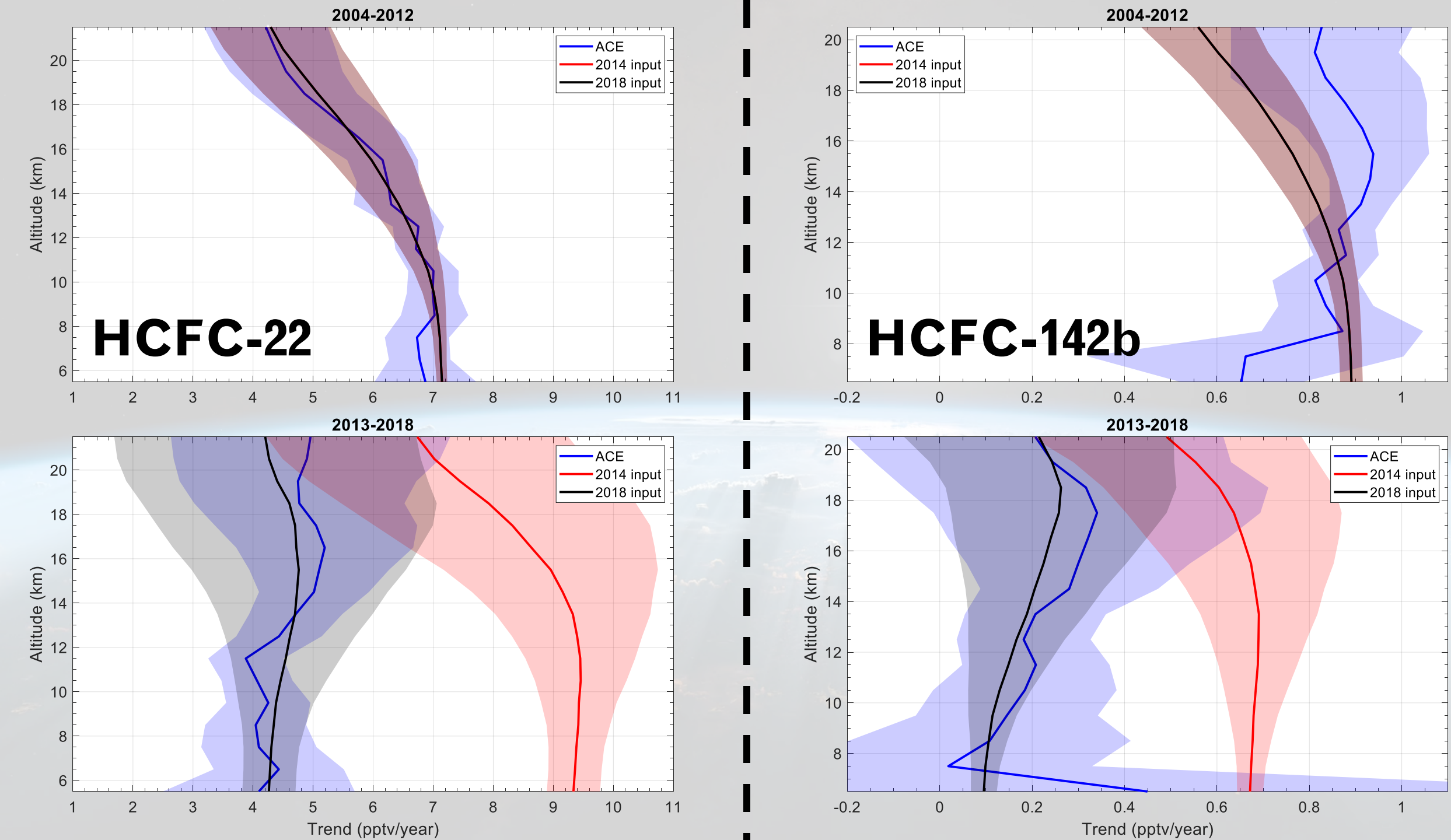
Shaded areas represent 99% confidence levels



- Near 7.5 km, significant differences in ACE-FTS measurements between pre and post 2013
  - ACE-FTS and control agree for 2013-2018
  - ACE-FTS and –emission do not agree below 9 km
- Differences in ACE-FTS trend values are more pronounced in NH
  - No significant difference in the SH



Global HCFC-22 and HCFC-142b


2004-2012
ACE
2014 input
2018 input
Altitude (km)
HCFC-22
2004-2012
ACE
2014 input
2018 input
Altitude (km)
HCFC-142b
2013-2018
ACE
2014 input
2018 input
Altitude (km)
Trend (pptv/year)
2013-2018
ACE
2014 input
2018 input
Altitude (km)
Trend (pptv/year)

Summary

- ACE-FTS had its sweet 16 this month!
  - Version 4 of the L2 data is now available; go download now and play!
- Near 8 km, ACE-FTS observes a significant increase in the CFC-11 trend after 2012
  - More pronounced in NH than SH
- The trend in CFC-11 concentrations below 9 km is significantly larger than in the scenario of no "extra" surface emissions
  - Effects are not distinguishable (beyond the uncertainty) at higher altitudes
- HCFC-22 and HCFC-142b trends are slower than what was predicted in 2014
  - Increasing trends are slower than if industry was phasing out at speed Montreal Protocol allows
  - ACE-FTS HCFC-142b trends in the 7-10 km region are not significantly different than 0 pptv/year (although they're fairly noisy…)

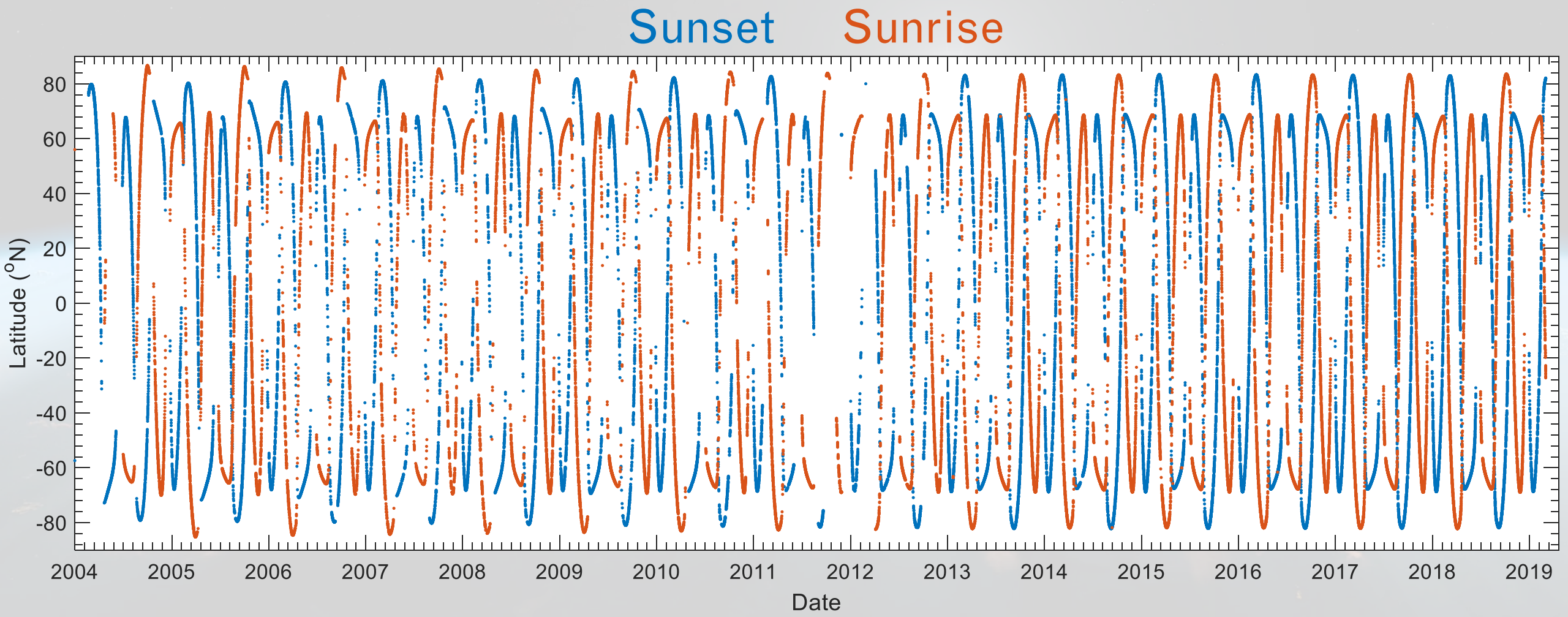
Thanks!

The extra bits...

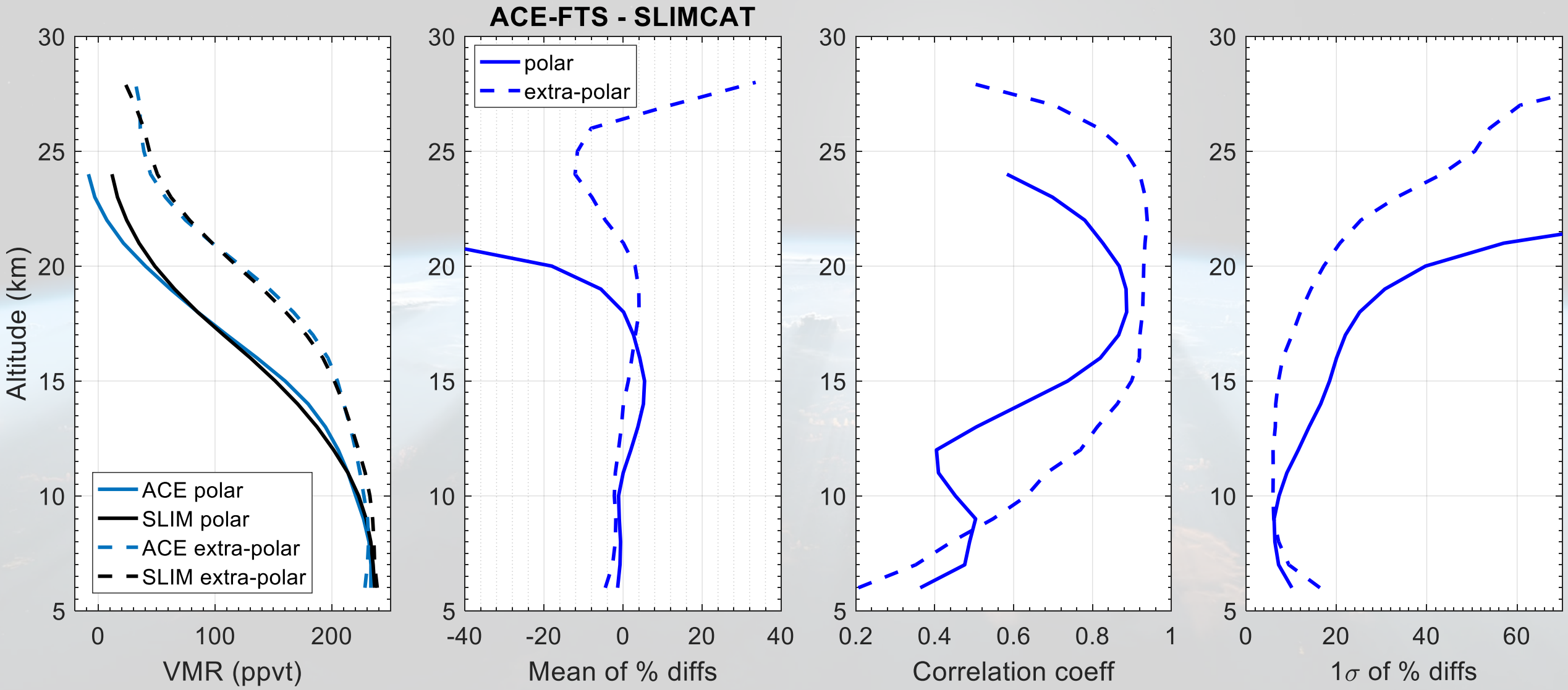
Linear regression

- Fit ACE-FTS and SLIMCAT data to model:
  - $f(t) = \underbrace{a + bt}_{\text{linear comps}} + \underbrace{\sin\left(2\pi(\phi_1 - t)\right)}_{\text{annual cycle}} + \underbrace{\sin\left(4\pi(\phi_2 - t)\right)}_{\text{semi-annual cycle}} + QBO_1 + QBO_2 + ENSO + Trop$
  - Fit is done for 2004-2012 and 2013-2018
    - Calculated errors shown are 99% confidence intervals

ACE-FTS global coverage

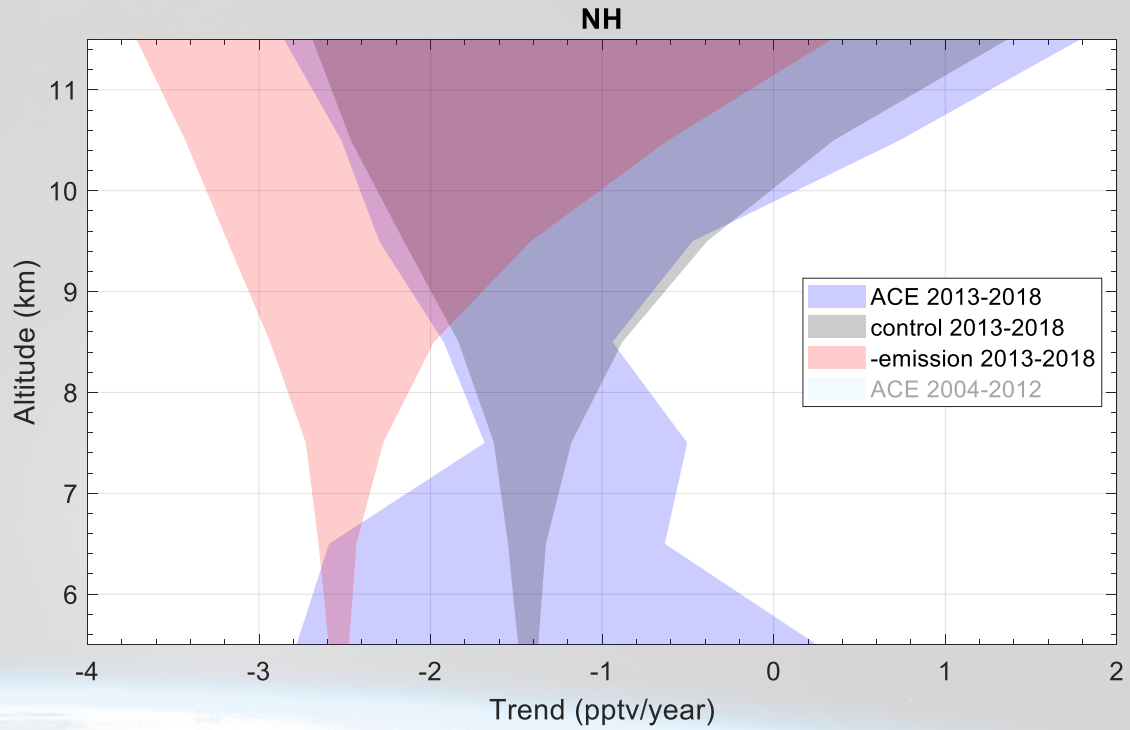


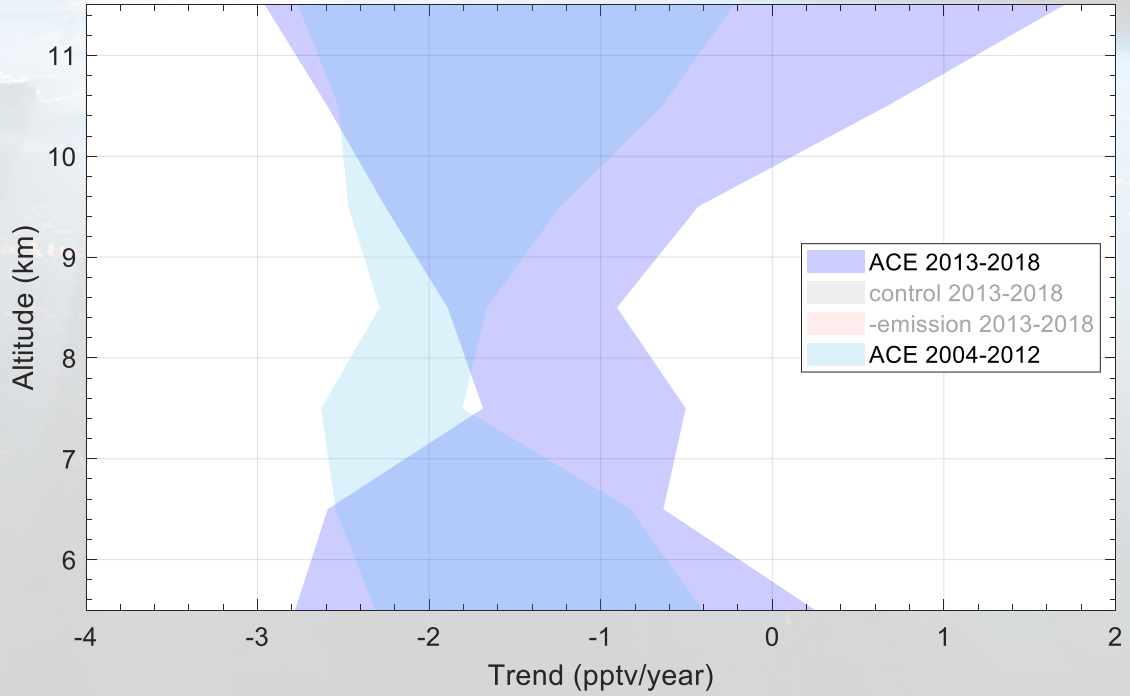
CFC-11 direct comparisons



CFC-11 hemispheric

- ACE-FTS trend values are only significantly different in NH (below 9 km)
- No significant difference in the SH





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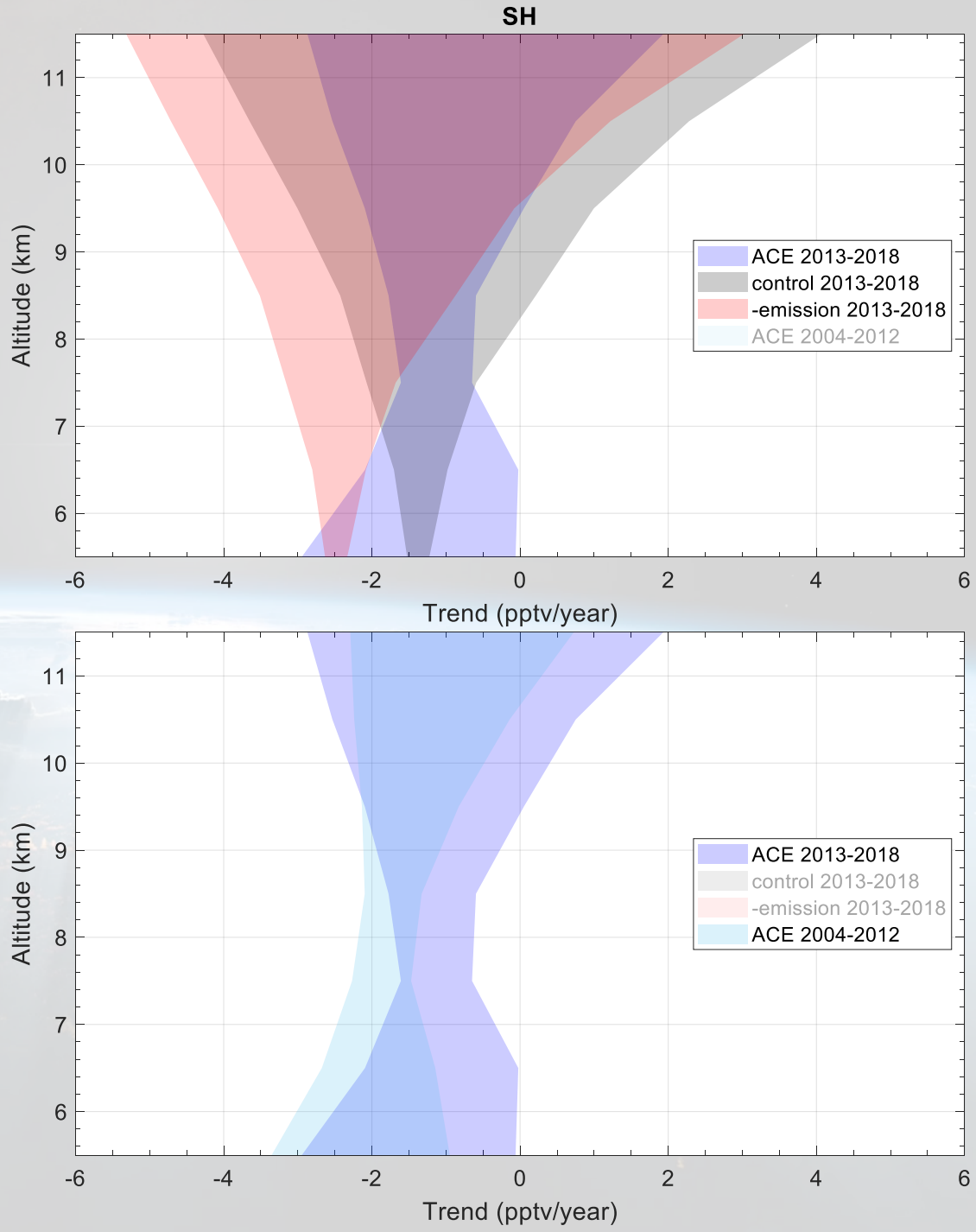
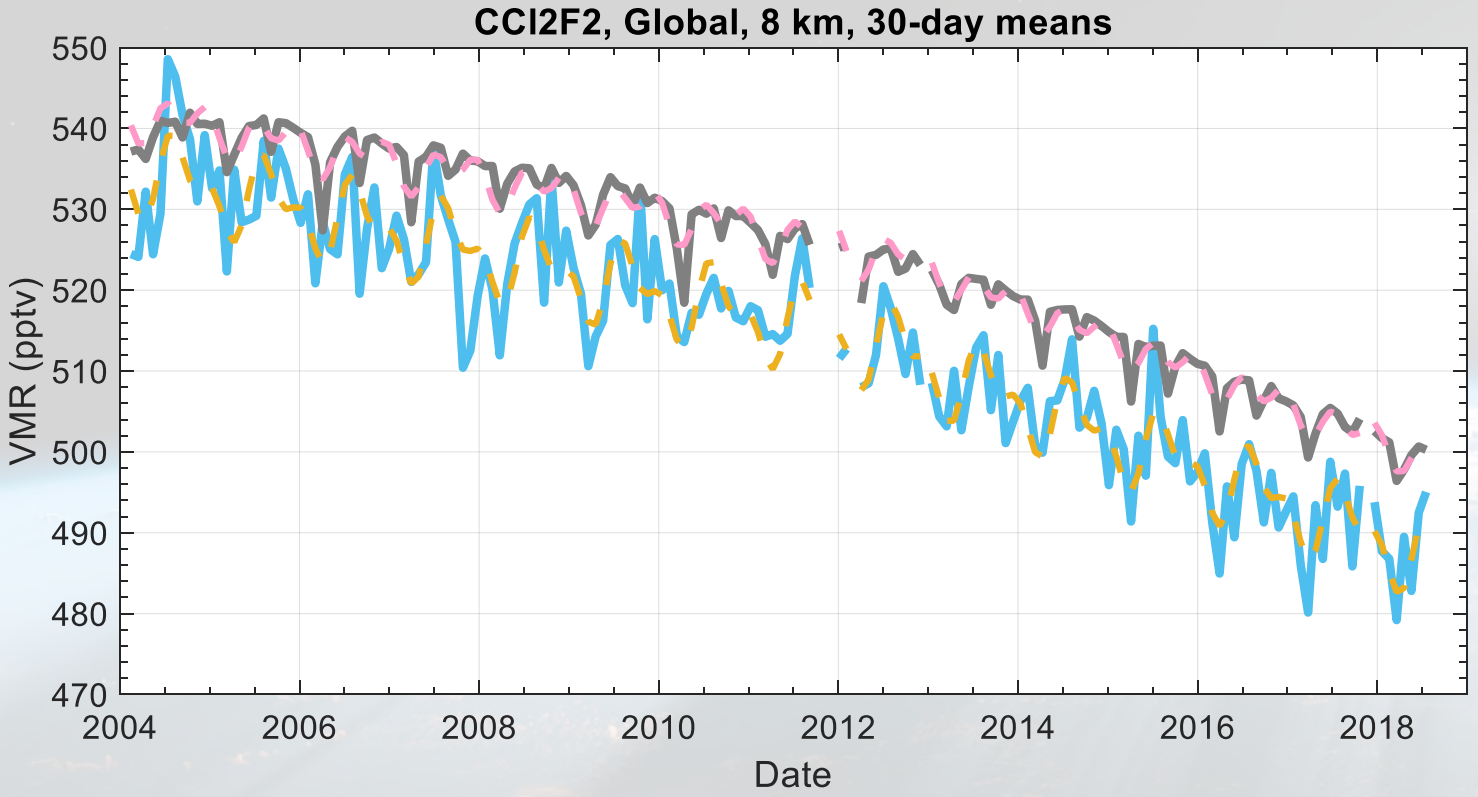
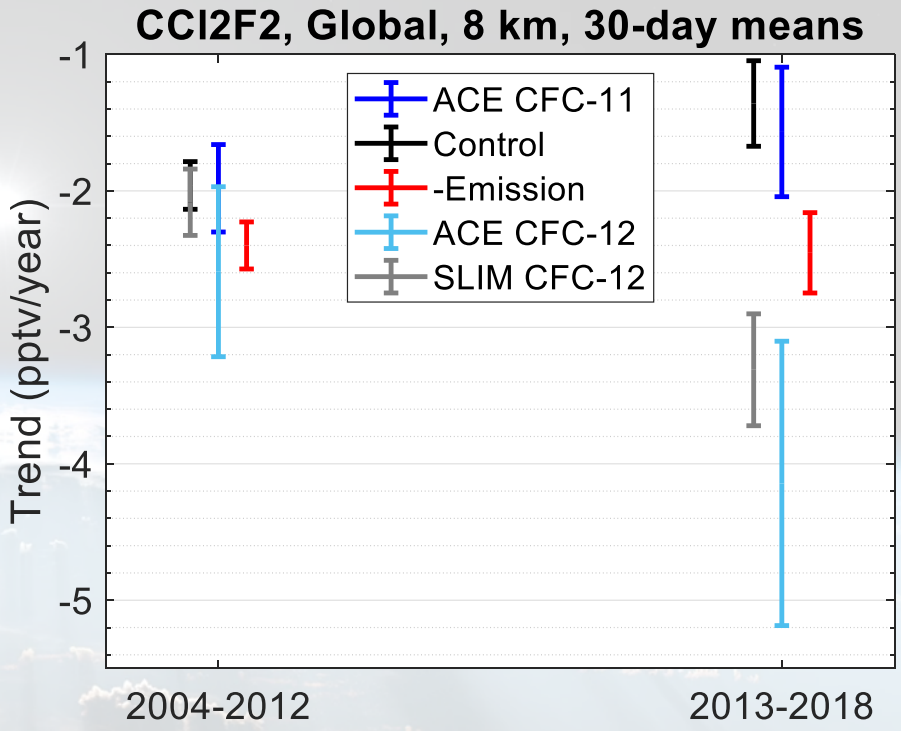
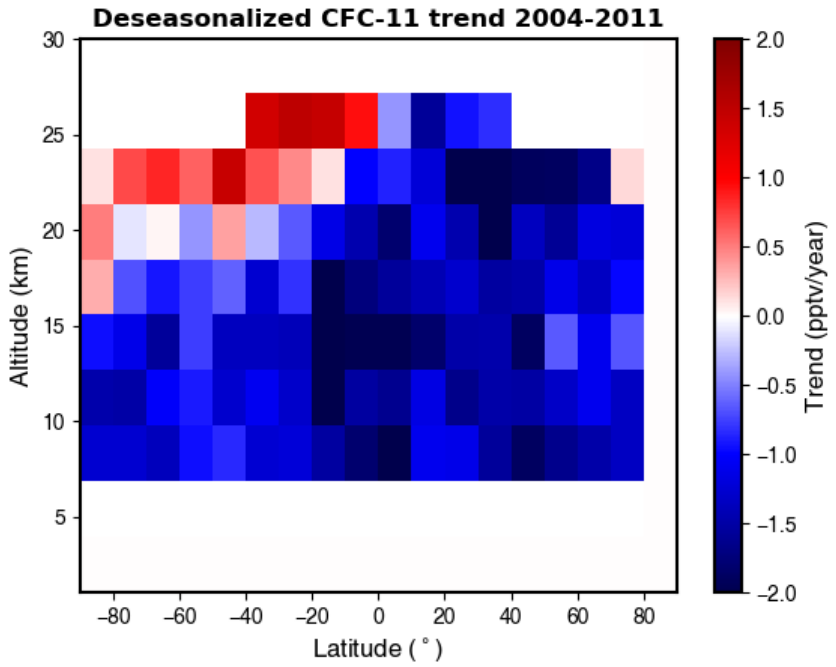


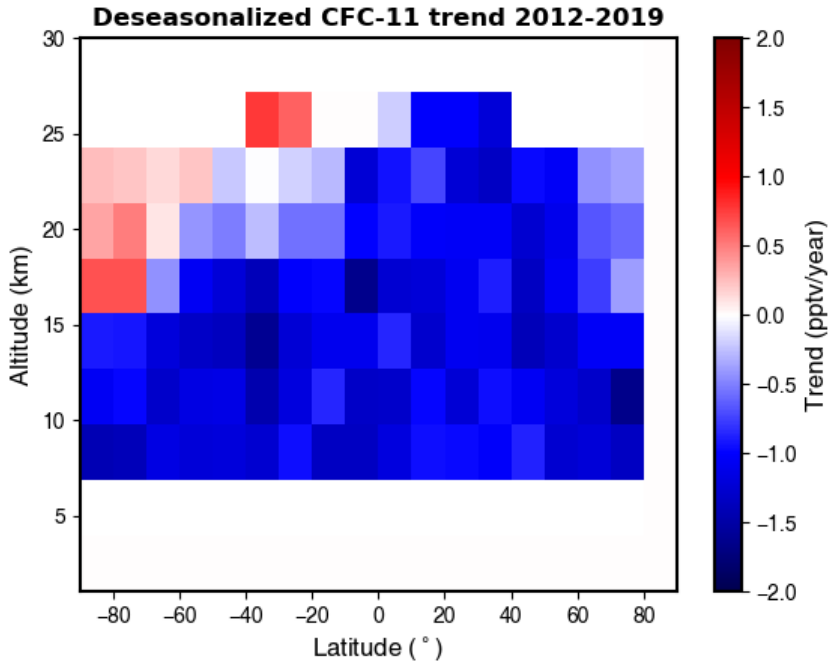
CFC-12

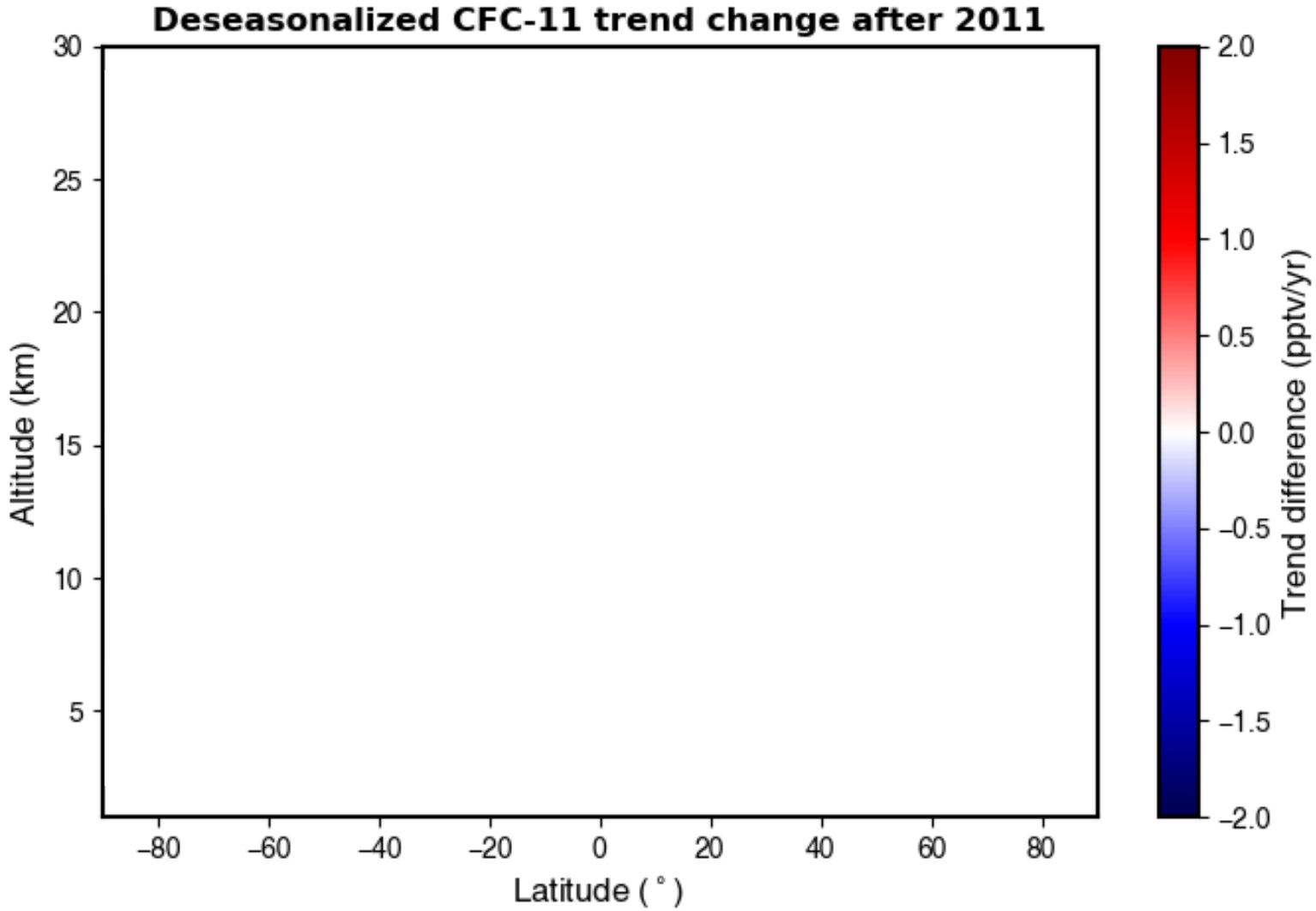




- ACE-FTS and CAT exhibit more negative trend of CFC-12 concentrations in 2013-2018 than 2004-2012
  - In both data sets, trend change is greater than combined uncertainties

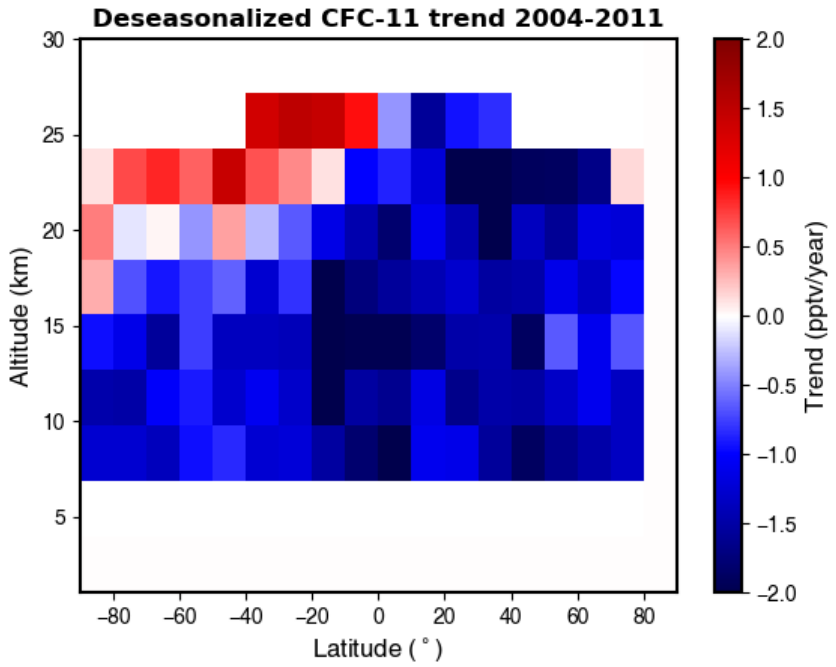


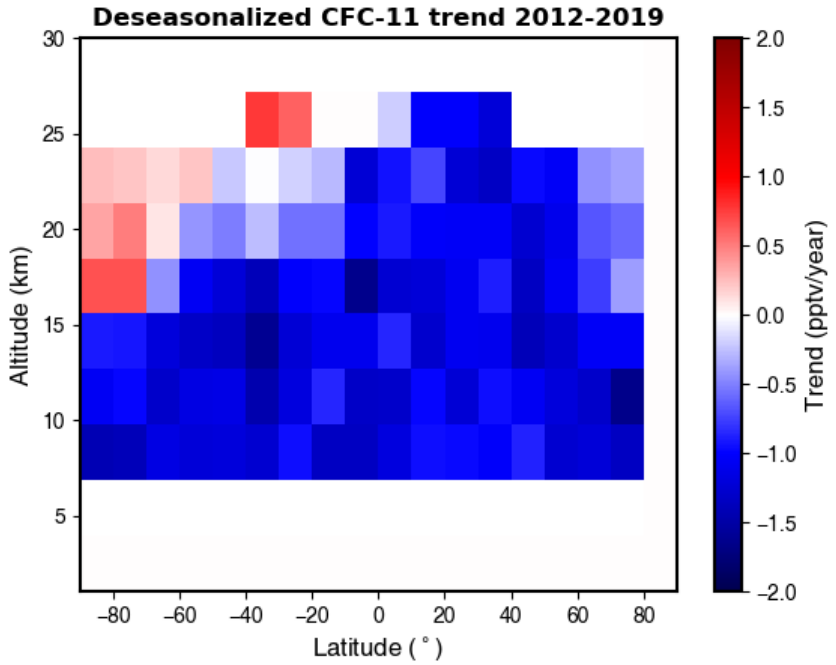


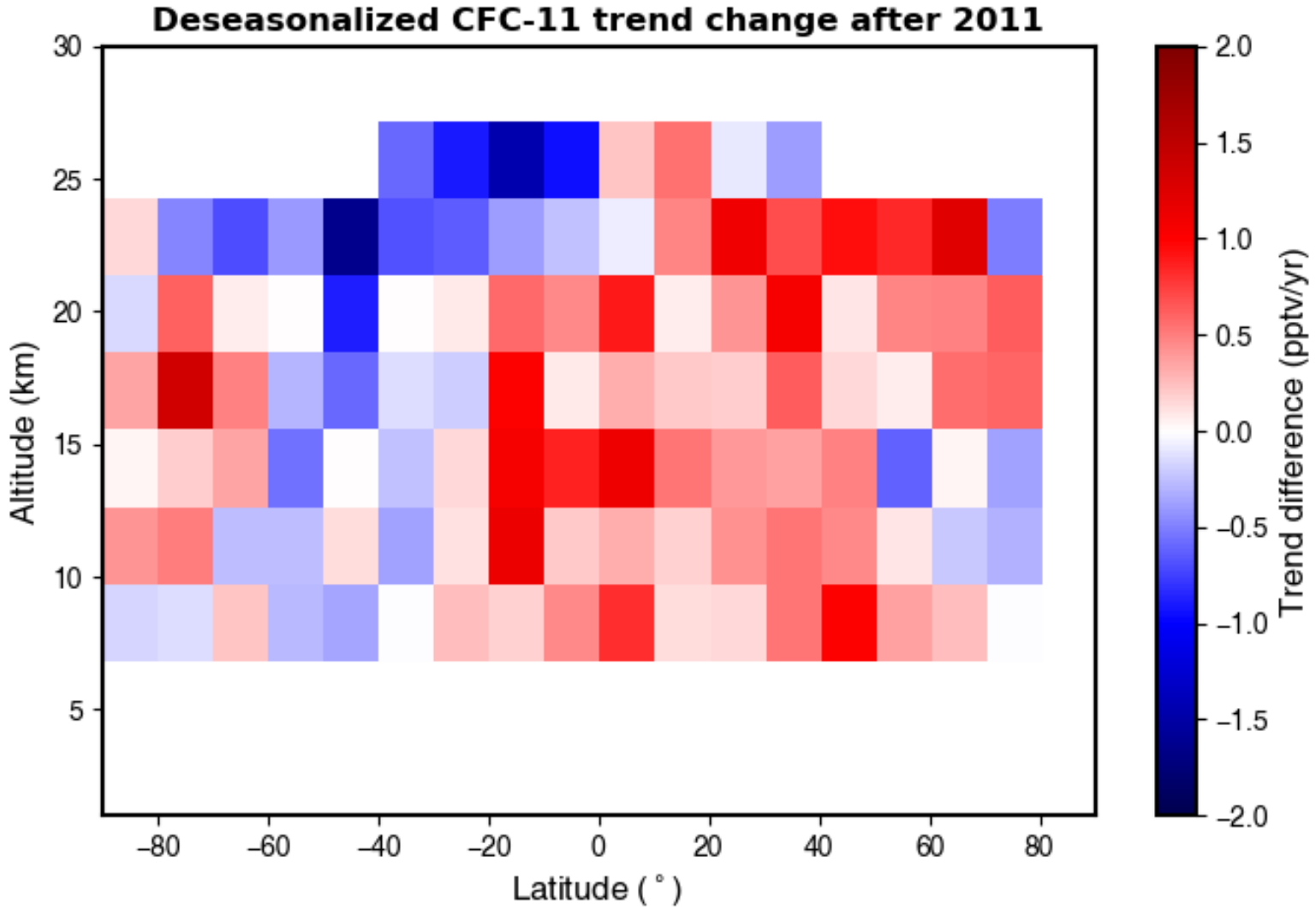


Change in trend is generally more positive than negative

- Especially in NH (compared to SH) in UTLS
- Changes are not greater than the combined trend uncertainties







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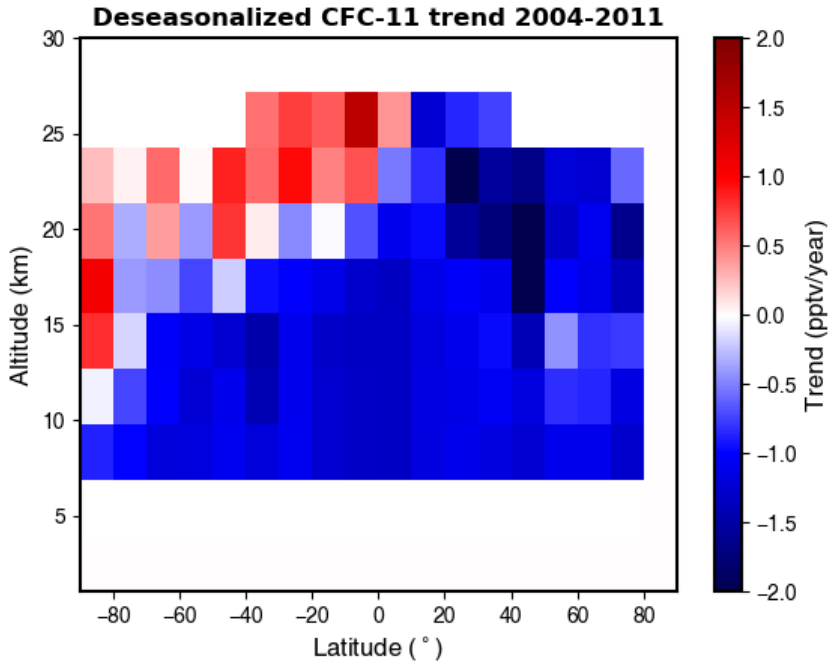
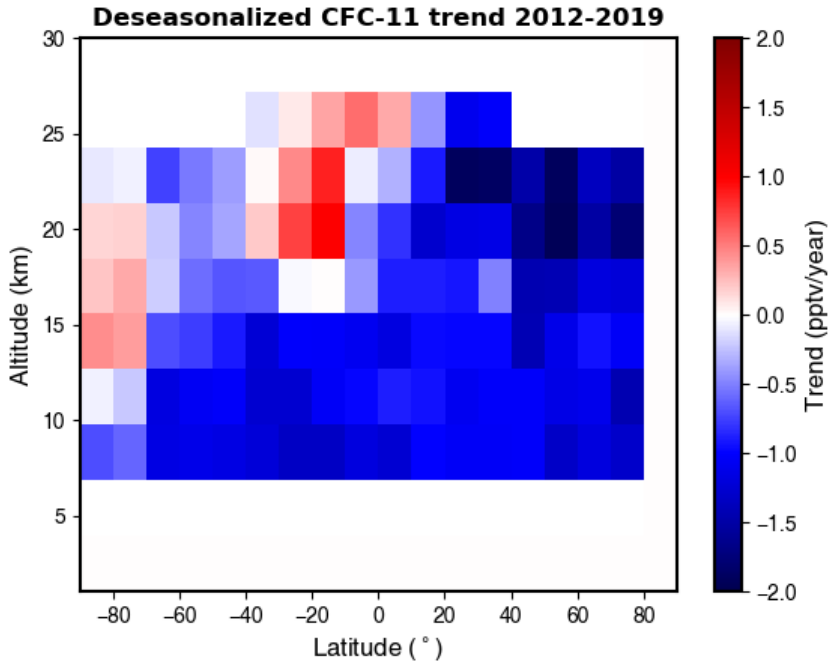
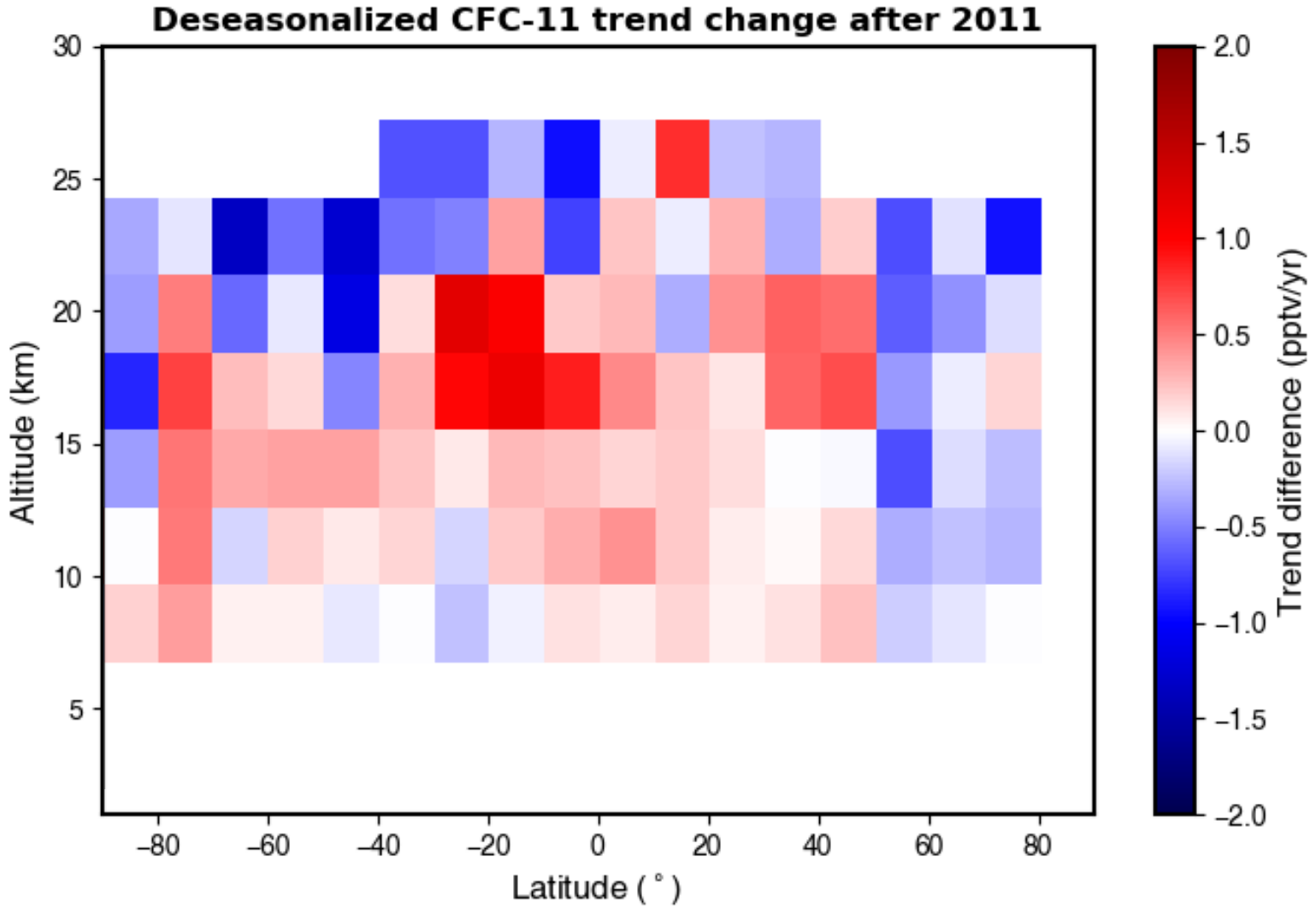
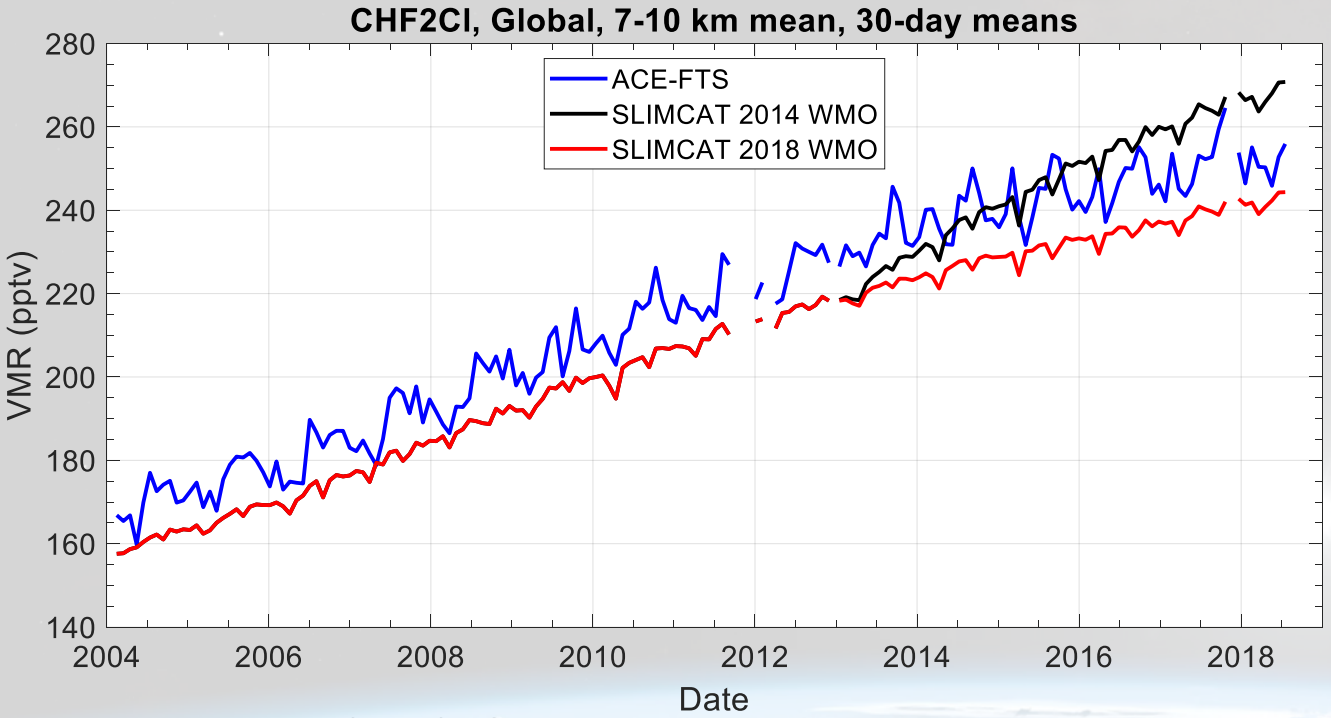


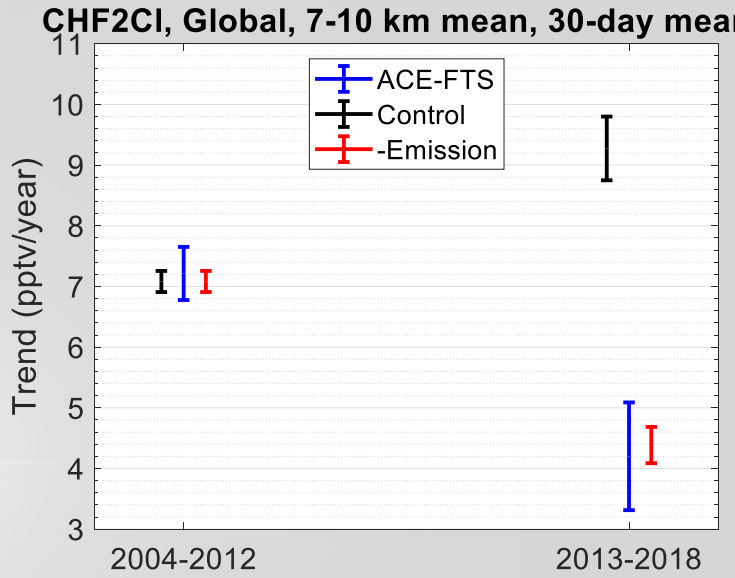


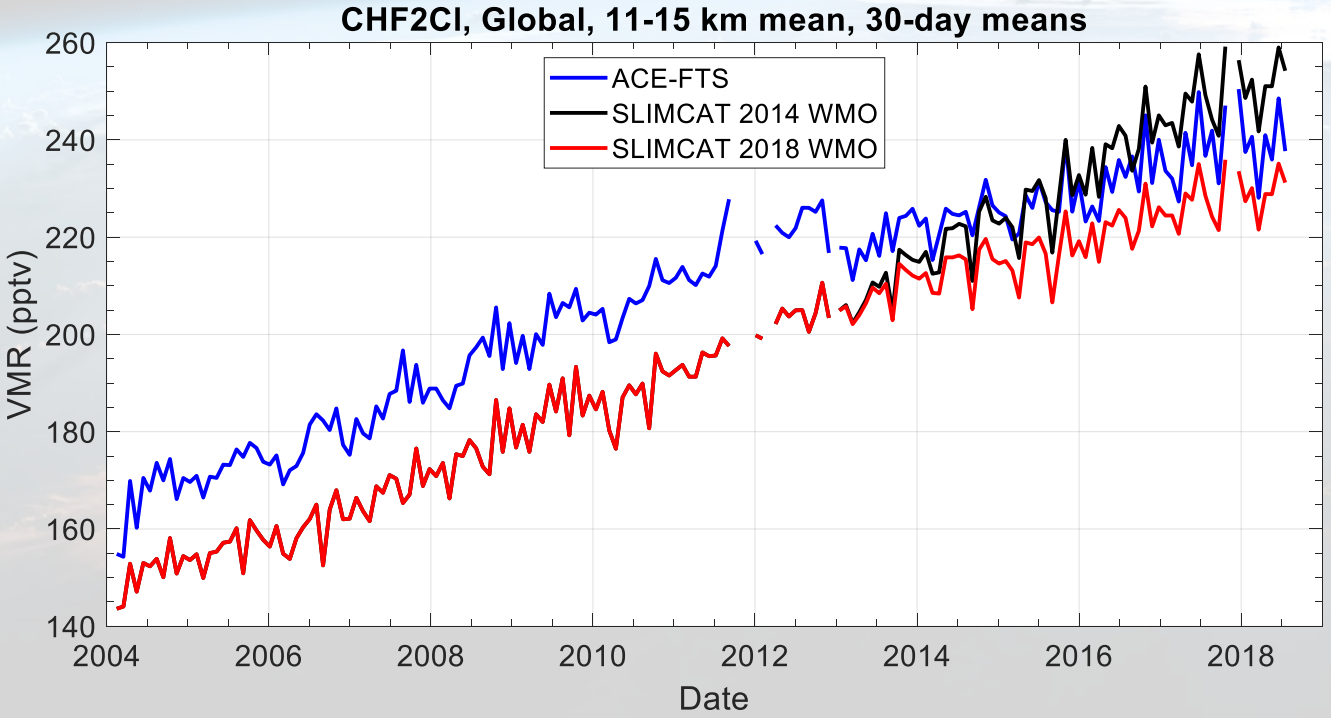


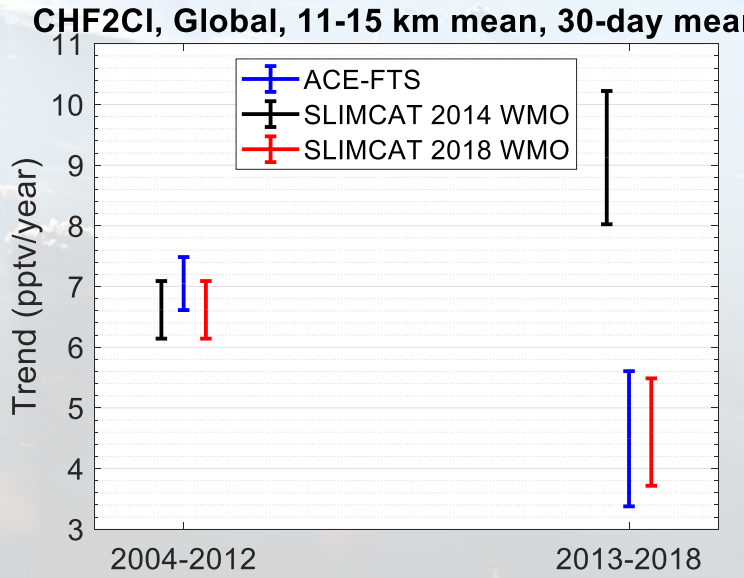
SLIMCAT Control

HCFC-22

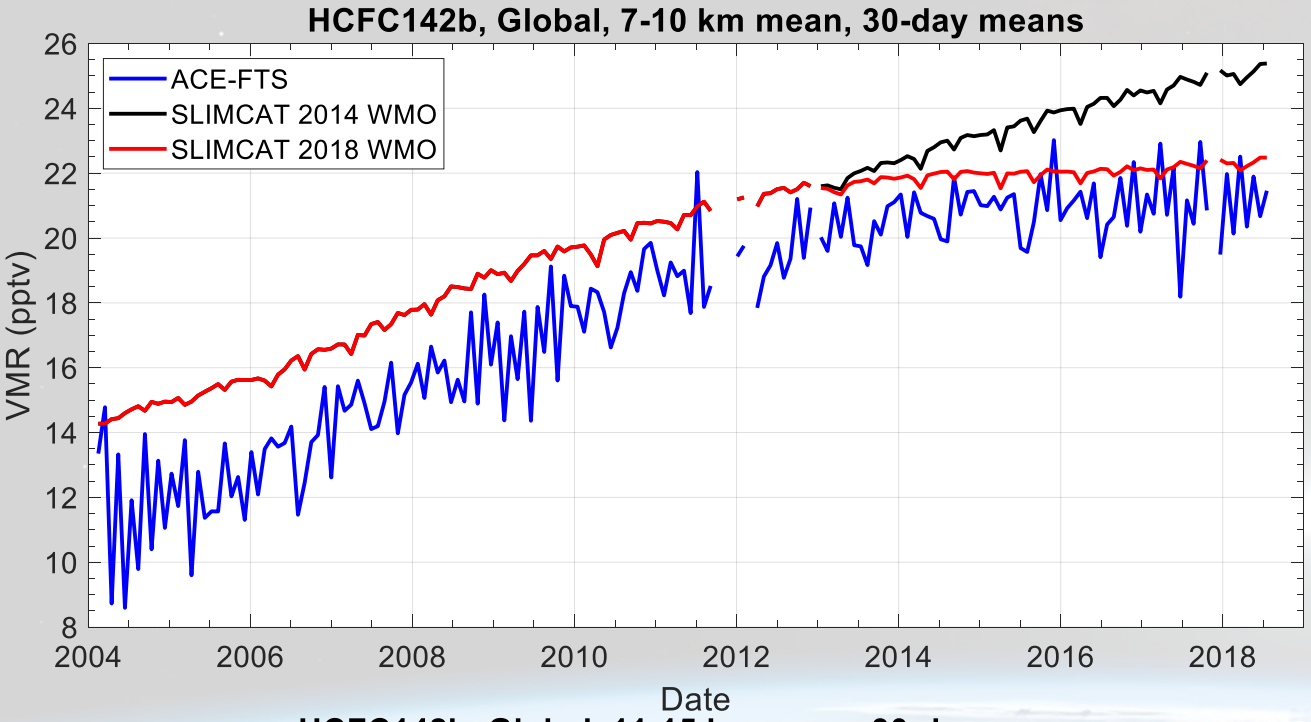

CHF2Cl, Global, 7-10 km mean, 30-day means
ACE-FTS
SLIMCAT 2014 WMO
SLIMCAT 2018 WMO
VMR (pptv)
Date


CHF2Cl, Global, 7-10 km mean, 30-day means
ACE-FTS
Control
-Emission
Trend (pptv/year)
2004-2012
2013-2018


CHF2Cl, Global, 11-15 km mean, 30-day means
ACE-FTS
SLIMCAT 2014 WMO
SLIMCAT 2018 WMO
VMR (pptv)
Date


CHF2Cl, Global, 11-15 km mean, 30-day means
ACE-FTS
SLIMCAT 2014 WMO
SLIMCAT 2018 WMO
Trend (pptv/year)
2004-2012
2013-2018

HCFC-142b


HCFC142b, Global, 7-10 km mean, 30-day means
ACE-FTS
SLIMCAT 2014 WMO
SLIMCAT 2018 WMO
VMR (pptv)
Date
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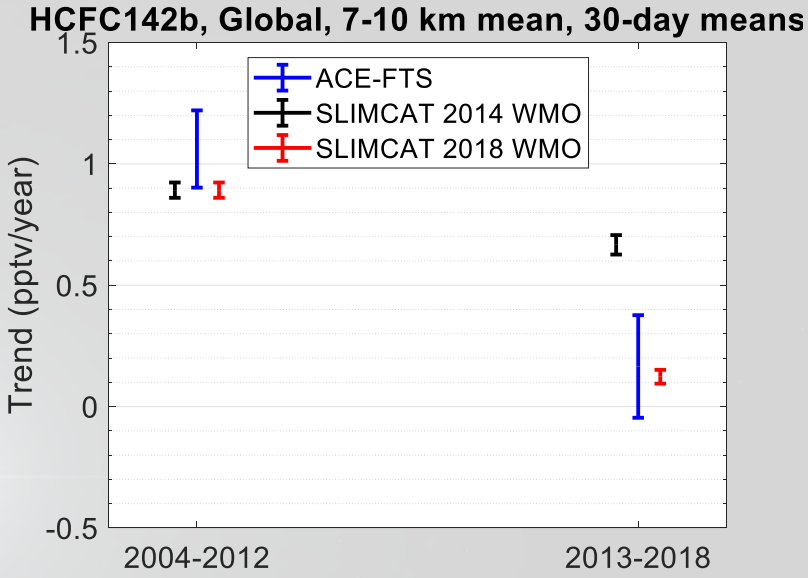
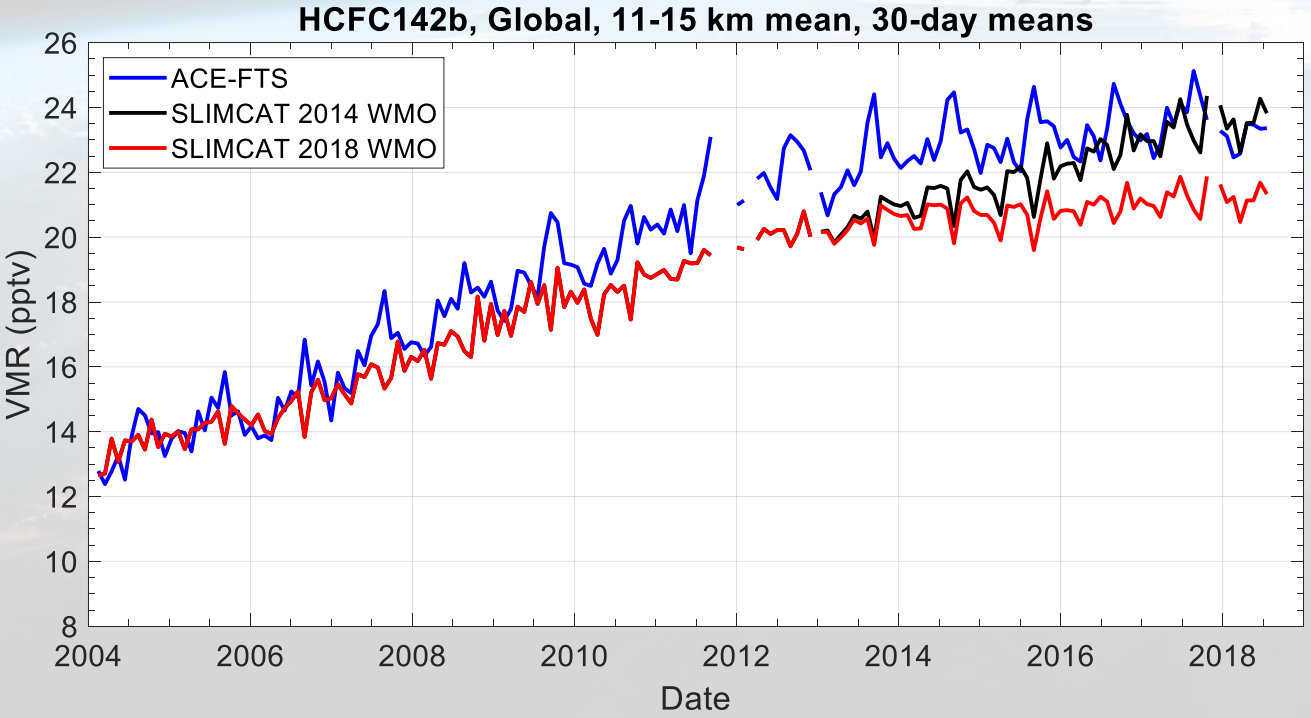
2014
2016
2018


HCFC142b, Global, 7-10 km mean, 30-day means
ACE-FTS
SLIMCAT 2014 WMO
SLIMCAT 2018 WMO
Trend (pptv/year)
1.5
1
0.5
0
-0.5
2004-2012
2013-2018


HCFC142b, Global, 11-15 km mean, 30-day means
ACE-FTS
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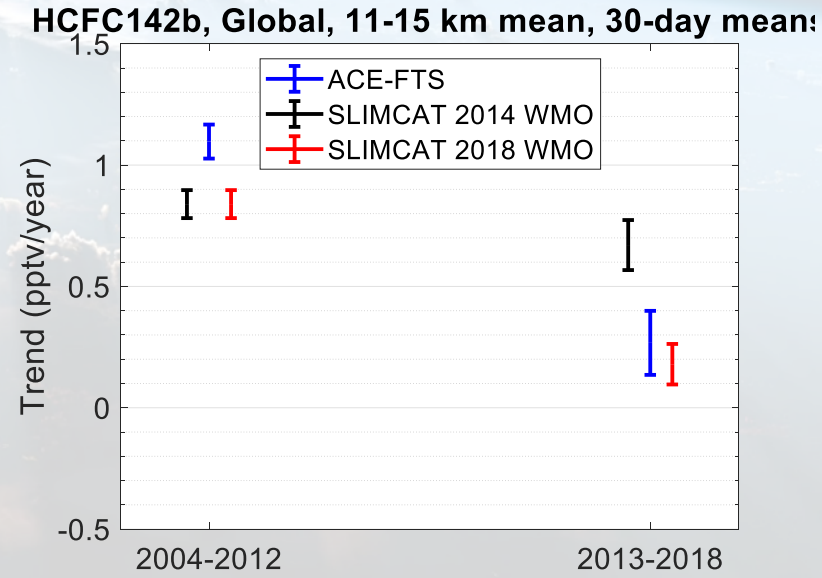
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1
0.5
0
-0.5
2004-2012
2013-2018